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ABSTRACT

Science is viewed as a neglected subject in many U.S. elementary schools. Many elementary school teachers feel unqualified and uncomfortable when asked to teach it. A study looked at a teacher who is enthusiastic about teaching science at the elementary school level. The constraints the teacher faced and ways in she dealt with them in her teaching were addressed. In order to examine the transition from university student to student teacher of this beginning teacher, she was observed during the 45-minute science period that took place 4 mornings a week. The data sources for this project were field notes taken during observations; transcripts of interviews with the student teacher, her cooperating teachers, students, and the principal; and documents including lesson plans, class handouts, and tests. Data analysis consisted mainly of inductive analysis in repeated examination of these data sources that led to the development of categories for organizing data. Assertions were generated and their validity tested by triangulating the various data sources. From the data, a picture of the student teacher's vision of teaching elementary school science, including her views on inquiry, textbooks, and group work was compiled. The constraints the student teacher perceived and the coping patterns used by the student teacher are discussed. The findings suggest that in order to implement reforms the position of the preservice teacher negotiating idealistic beliefs about science teaching within the existing school structure must be taken into account. This study established a theoretical base from which we can begin to understand science enthusiasts among prospective teachers and their transition from novice to experienced teachers. (34 references) (KR)

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Coping with Constraints of Teaching Elementary Science: A Case Study of a Science Enthusiast Student Teacher

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Abstract

Science is a neglected subject in U.S. elementary schools; most elementary school teachers feel unqualified and uncomfortable when asked to teach it. But what becomes of those few elementary teachers who are enthusiastic about teaching science? What constraints do they perceive and how do they teach science in the face of these constraints? This case study of one elementary school student teacher attempted to answer these questions.

Marie was known among elementary education faculty as a science enthusiast and had expressed a desire to be an elementary science specialist. In order to examine the transition from university student to student teacher of this beginning teacher, I (Abell) became a participant observer in Marie's fourth grade class for the 9-week student teaching experience. During this time I observed the 45-minute period which took place four mornings a week.

The data sources for this project were (a) field notes taken during classroom observations, (b) transcripts of interviews with Marie, her cooperating teachers, students, and the principal, and (c) documents including lesson plans, handouts, tests, and methods course products. We analyzed the data using inductive analysis in which repeated examination of these data sources lead to the development of categories for organizing the data. We also generated assertions and tested their viability by triangulating the various data sources.

From the data we have induced a number of coping patterns which Marie knowingly and unknowingly used to address the constraints she perceived to her science teaching. These constraints included expectations from the cooperating teacher and university supervisor, cultural norms of the fourth grade teachers, inadequacy of equipment and textbook, and accountability for student learning as demonstrated on textbook tests. In coping with these constraints, Marie tried to saturate the curriculum with science, even finding additional time in the school week to conduct science lessons. She activated other teachers in their science teaching. At times she complied with perceived expectations, but typically by modifying the constraining factor to produce a hybrid result. Her strategies are somewhat unique for a novice, but may be influenced by her position as science enthusiast and by the traditionally low status of science in the elementary school curriculum.

The findings of this study have implications for science teacher preparation, student teaching programs, and the current reform movement in science education. To implement reforms we must take into account the position of the preservice teacher, negotiating idealistic beliefs about science teaching within the existing school structure. This study establishes a theoretical base from which we can begin to understand science enthusiasts among prospective teachers and their transition from novice to experienced teachers.

Introduction

> I guess that's a big concern that I have through the years of teaching. Ya know, what's to keep me from being a teacher who's been in a classroom 15 years and is teaching the same way? (Interview, 3/26)

What happens to the vision of a beginning teacher as she progresses through her teaching career? We need teachers who are enthusiastic toward teaching science (we will call them science enthusiasts) to remain so throughout their careers if we are to change the bleak picture of elementary school science education in this country. Science is the most neglected of the academic subjects in U.S. elementary schools, occupying an average 10% of total instructional time (Goodlad, 1984). In the 1986 National Assessment of Educational Progress 40% of third graders reported conducting no science experiments in the previous month and another 19% reported never performing experiments in science class (Mullis & Jenkins, 1988). This is not surprising when 90% of surveyed elementary school teacher report covering over 75% of the textbook in science (Weiss, 1987). Perhaps this is because elementary school teachers feel unqualified and uncomfortable when it comes to teaching science (Weiss, 1978, 1987).

The science education community is presently undertaking several reform efforts (Landes et al., 1988; Rutherford & Ahlgren, 1990; Weiss, 1990). All such efforts, however, depend upon teachers for their ultimate success. It would thus behoove us to understand more about teachers and the constraints they perceive within schools when they attempt to implement science programs beyond the textbook-driven curriculum. As a start, we could try to better understand what happens to preservice teachers who are science enthusiasts when they encounter the public school culture, as well as to discover how elementary teachers become science enthusiasts.

The research base concerning student teachers is broad and varied. Researchers have examined the developmental concerns of student teachers (Fuller, 1969), their roles and beliefs (Tabachnick, Popkewitz, & Zeichner, 1979-80; Zeichner, 1983;), their socialization (Etheridge, 1989; Hoy & Woolfolk, 1990; Lacey, 1987; Zeichner & Tabachnick, 1981), and their views of success and failure (Borko, Lalik, & Tomchin, 1987; Ellwein, Graue, & Comfort, 1990). Only a few from the myriad of student teacher studies actually report what happens to novice teachers in the classroom. Shulman (1987), for example, described the adaptation process of a high school English student teacher whom she observed and interviewed during a 10-week term. Unfortunately, similar studies of elementary school student teachers and their science teaching are nonexistent, as evidenced by our unproductive computer search of the research literature from the last 20 years.

This case study is part of an ongoing long term study exploring the process of becoming an elementary school science

teacher. In the present report, we examine the transition from university student to student teacher of one novice teacher, Marie. The initial objective of the study was to describe the constraints perceived by a science enthusiast student teacher as she attempted to teach science in accord with her beliefs. This analysis is discussed in detail in another report (Abell & Roth, 1991). As the research progressed, the data suggested another question to investigate: How does a novice cope with conflicts between her beliefs about science teaching and learning and the constraints she perceives to her teaching? Marie's strategies for coping with perceived constraints form the focus of this report.

One framework for examining the socialization of student teachers has been developed by Lacey (1987) based on his case study of secondary student teachers in England (Lacey, 1977). Lacey asserted that student teachers use three strategies to cope with constraints. The first, internalized adjustment, occurs when the individual complies with constraints and believes they are for the best. The second and most frequently observed strategy, strategic compliance, occurs when the individual complies yet retains personal reservations about his or her actions. A final strategy, strategic redefinition, occurs when students face constraining situations with new knowledge, skills, and values to bring a new solution to bear on the problem. We will examine the extent to which Marie's emerging patterns for coping with perceived constraints fit into Lacey's model.

Theoretical Framework and Methodology

As the research instrument in a naturalistic study (Goetz & LeCompte, 1984; Wolcott, 1975) the researcher's theoretical position affects the questions asked and the observations made, as well as the interpretations generated. This study is based on a set of assumptions about the nature of learning and the "nature of cause in human social relations" (Erickson, 1986, p. 125). A constructivist epistemology (von Glasersfeld, 1987, in press) and a symbolic interactionist research approach (Blumer, 1969; Jacob, 1987) form the guiding framework for this study. This framework leads us to assert that our research is a process of interpreting meaning constructed by community members, rather than reporting an objective reality.

The holistic case study provides a way to understand the complexity of teacher socialization by allowing the interpretation of events within a real-life context (Yin, 1989). Case studies seek to describe a specific configuration of events and then to establish theoretically valid inferences. Yet to be externally valid, the case need not necessarily represent the average:

> . . . the search for a "typical" case for analytical exposition is likely to be less fruitful than the search for a "telling" case in which the particular circumstances

> surrounding a case serve to make previously obscure theoretical relationships suddenly apparent. (Ellen, 1984, p. 239)

This study is an in-depth look at the "telling" case of one student teacher, Marie, who was purposively selected (Patton, 1980) from one section of a science methods course that immediately preceded the 9-week student teaching experience. Marie was known to be active in the School of Education's student government and a science enthusiast: she had volunteered during "science days" in local elementary schools, taken part in environmental education workshops, attended the state science teachers convention, and expressed the desire to become an elementary science specialist at some point in her career. This combination of professional maturity and science teaching enthusiasm made Marie an ideal candidate for study. After I (Abell) described the proposed research methodology and explained my objective to learn more about students once they leave the science methods course (of which I was the course coordinator, but not Marie's instructor), Marie decided to become involved in the project. She thought that her involvement would benefit her professional development. Her perception of being a collaborator rather than a subject in this study was illustrated several times throughout the course of the nine weeks. For example, during a stressful time in her teaching, I asked if my presence in her classroom was a disturbance. She replied, "No, this is different, because we have a plan. I mean this is part of what I'm doing" (Interview, 4/12).

The data sources for this project were (a) field notes, (b) interview transcripts, and (c) documents including lesson plans, handouts, tests, and products from the science methods course. During the 9-week student teaching event I was a participant observer in the fourth grade classroom of a largely rural county school system near a mid-sized university and manufacturing city. I observed during the 45-minute science period which took place four mornings a week. This observation schedule was interrupted twice, once by standardized testing and once by my own travel. In addition, during week 7, I spent one entire day in the class. I observed a total of 20 science classes. I elaborated upon each day's field notes by reviewing audiotapes of the lesson.

Structured and informal interviews were constructed following guidelines from Patton (1980). After most science periods, while students were at recess, Marie and I discussed the lesson. We also arranged for several structured interviews away from the school site. In addition, I conducted interviews with Marie's cooperating teacher, the class science teacher, the principal, and several students. All interviews were transcribed from audiotape recordings. Interviews with Marie were essential in interpreting classrooms actions and thus became the primary data source for analysis, triangulated with the field notes and documents.

Data analysis has been conducted collaboratively (Dillon, O'Brien, & Ruhl, 1989) by the researcher and the student teacher. We employed inductive analysis (Bogdan & Biklen, 1982; Goetz & LeCompte, 1984) in which repeated examination of field notes, interview transcripts, and documents led to the development of categories for organizing the data. Concurrently we generated assertions and tested their validity by seeking confirming and disconfirming evidence from multiple data sources (Erickson, 1986, Yin, 1989).

Findings

In a previous report we discussed how Marie's teaching practices interacted with her beliefs about science teaching and learning and with the constraints she perceived in her position as a student teacher (Abell & Roth, 1991). These findings form the baseline for understanding Marie's coping strategies, and so we begin by summarizing them.

From the data we have composed a picture of Marie's vision of teaching elementary school science. The values of hands-on and personally relevant experiences emphasizing the science process skills in a small group setting formed the core of Marie's beliefs about science teaching and learning. These beliefs were threatened by perceived external constraints including: expectations from the cooperating teacher and university supervisor, cultural norms of the fourth grade teachers, inadequacy of equipment and text, and accountability for student learning as demonstrated on textbook tests. Furthermore her teaching was influenced by her limited content and pedagogical content knowledge.

Marie was not a typical student teacher: she was a science enthusiast, she was a leader in student government, and she had many teaching experiences prior to student teaching including teaching in summer gifted programs and in the National Energy Education Development Project. When she arrived at Lincoln Elementary School*, her cooperating teacher, Mrs. Marsh, also described her as atypical: "Marie is definitely an exception to most student teachers. She came in with a lot of confidence" (Marsh, Interview, 4/19). Likewise, Mr. Dawson, who was the science teacher for Mrs. Marsh's class, commented on Marie's exceptionality:

> Overall I've worked with any number of student teachers while I've been here at Lincoln. And watching Marie, although I did not watch her through an entire day by any means, she just seemed to be a much more independent thinker and much more motivated, self-motivated, self-starter type of person than most other student teachers I've had. She seems to be much more mature in her position with the kids. She's not the least bit intimidated and not the least bit nervous about jumping right in and going, where that has not always been the case with student teachers. She started her

*All names, except Marie's, are fictitious for purposes of confidentiality.

> science lessons from the very first day she took over. There was no phasing in, phasing out and she plans to teach right up until Friday when she leaves. (Dawson, Interview, 5/4).

Marie's singular nature as a student teacher can also be reflected in how she coped with the constraints she perceived to her teaching. From the data we have induced a number of coping patterns which Marie consciously and subconsciously used to address the constraints she perceived. We will call these patterns saturation, activation, and hybridization, and after defining and illustrating each pattern, we will compare them to Lacey's (1987) categories in the socialization of student teachers.

Supersaturation: Science everywhere

Even before Marie took over teaching the science class in week three, she had plans to saturate the curriculum with science. Her first move was to set up an aquarium/terrarium in the class, an activity she had participated in during her college biology course for elementary school teachers. On the first day of student teaching she organized groups to draw a plan for the terrarium and she set up a chart on which students had already started to record observations about the organisms in the aquarium side of the tank. Seven weeks later field notes indicate that student interest in the tank was still high:

> New items are in the tank today--a zebra fish and a frog...8:59 Neil notices more fish in the tank...9:15 Neil and Carl draw others' attention to the frog in the fish tank. Most of the class runs up to see while Marie passes out math worksheets. (Field notes, 4/17)

Even though the fish tank was used informally, outside of science class proper, it became an important science activity. According to one student, Ken:

> I think what I like about science is that she brought in that fish tank, aquarium, and that we spreaded it out and we put in some seed and all that. And then she got some tadpoles and some goldfish. And then she told us that we could observe, observe what we see in there like, I saw we added two little pond snails and when you look at it real good you can see the pond snails 'cause they blend in with the color. (Ken, Interview, 3/20)

Marie saw the aquarium as a way around the accountability of worksheets and exams, as a way to do science as she wanted. Because she operated outside of the formal science time, she felt less constrained by content considerations.

> Like with this aquarium, this aquarium has <u>nothing</u> to do with the content. Nothing to do with the worksheets, and all the other stuff. But the kids have done <u>more</u> investigations and have learned <u>more</u> process skills, they've done more science experimenting with that ten gallon tank in the corner of the room than anything else. (Interview, 4/17).

Marie tried to saturate the curriculum with other informal science opportunities. One day she hung prisms in the window and waited to see how the students would react when little rainbows appeared all around the room. She changed from language arts

activities to science for the class treasure chest, where students chose nine activities to complete sometime during a given month. "I'm really trying to develop more, making that a science treasure chest for April" (Interview, 2/23). She planned that April would center on Earth Week celebrations, and that bulletin boards, learning centers, and the treasure chest would be "revolving around different science things" (Interview, 3/1). She even integrated science into physical education: "I teach gym once a week...So I was gonna do a lot of Project WILD during those times" (Interview, 3/2).

Not only did Marie try to infuse science throughout the day in informal ways, she actually tried to relegate more time for science. Once a week the students had computer class. The group was split in half and fifteen students went with Mrs. Marsh to the computer lab while fifteen stayed in the room completing seat work with a parent aide; then the groups switched. Marie asked Mrs. Marsh if she could use that time to do science.

> And then I'll do science with the fifteen kids. And that way I can do a lot more outdoor things, and a lot more hands-on and the groups will be more manageable. (Interview, 3/1)

Although Marie used the saturation strategy to infuse science at more times throughout the school day, it does not appear that she was always consciously reacting to perceived constraints. Instead it seems that science was an enabling subject and that somehow her science-enthusiast position allowed her to do things that did not appear possible in other subjects. A conversation about math problem solving activities illustrates this assertion:

> Well, I always thought I'd do them like on a Friday. Ya know, in the afternoon stick it in. We would just do a problem solving activity. I didn't know how that would work in this structure because there just isn't any time. You can't add anything. (Interview, 3/1)

Although Marie perceived constraints to her science teaching, she forged ahead with supersaturating the curriculum, trying to add science beyond what was usual. In math, on the other hand, her perception was that this strategy was not possible.

Activation: Affecting other teachers

Marie served as a catalyst for science at Lincoln School, often unknowingly. The first indication of her activation energy was in reference to her belief in group work. Although warned by the other fourth grade teachers that group work in science would be a disaster, Marie persevered. From the day she took over science teaching until the end of her student teaching tenure, Marie organized her science teaching with small group work. Toward the end of her nine weeks at Lincoln, Marie noticed that other teachers down the hall had switched their room organization from rows to groups:

> While kids work Marie tells me that Mr. Dawson now has his class organized in groups of five and the teacher next door has three large groups. Marie says, "And they said this isn't done here. It wouldn't work." Marie seems gleeful about this. (Field notes, 4/17)

Several people at Lincoln found Marie's enthusiasm for science to be motivating. The school principal described what he perceived as Marie's affect on the staff:

> To have somebody like Marie come in who is real excited about science education has stimulated the whole 4th grade and I suspect probably the 5th grade to some extent...Certainly Marie brings some things to 4th grade or 5th grade that are real unique. And certainly her interest in science is one of those. And with her enthusiasm, it's been infectious. And so we have people down there who are really thinking science now. (Principal, Interview, 5/4)

One example of this activation took place toward the middle of student teaching. Marie's students had made tornadoes in bottles, which were sitting on their desks. When two classes came together to hear a guest speaker, the other students noticed the tornado bottles and were envious. Marie remarked that some of the other fourth grade teachers came in later to find out more about the activity.

Marie's cooperating teacher, Mrs. Marsh, was also influenced by Marie. Toward the end of student teaching Mrs. Marsh spent many hours photocopying science ideas from Marie. According to Marie, "I leave things on her desk and they come back in duplicate" (Interview, 4/12). Mrs. Marsh did not teach science. Instead she teamed with Mr. Dawson who taught science while she taught social studies. Yet as she began to contemplate teaming with another teacher, Debbie, in the upcoming year, she reconsidered her position about science.

> Debbie said, in the middle of what we were talking about, "I'm certainly not going back to teaching science." And I said, "Well, I might even try it!" She said, "Really?" I said, "Marie has given me inspiration." And so...I told Debbie, I said, "I might go ahead and consider it." And she looked at me. And I said, "Really, you teach social studies and I'll teach science." I said, "I think I've learned enough from Marie..." (Marsh, Interview, 4/19)

Marie even influenced another student teacher in the building; after witnessing Marie's success with the aquarium, she decided to ask for a tank for a graduation gift.

Marie's affect on Mr. Dawson was more ambiguous. When she first started to teach science, he would come to class to observe and take notes on ideas that he felt were useful. Soon he stopped coming to class and Marie was on her own in science. Mr. Dawson felt he could re-envision his science teaching if the school would change to a more departmentalized situation where he had a room equipped for science, instead of being expected to teach all subject areas. "I just think it could be as Marie has done. I think it could be made into something completely different than it is now" (Dawson, Interview, 5/4). Yet Mr. Dawson felt limited by the constraints he perceived. Furthermore he attributed Marie's success in part to her university

connection (for the equipment she could obtain) and in part to the quality of her students.

> I think she also had the advantage of that was a good group to try it on. I really think that's a good group of students to try it out on. I think she might have gotten a totally different reaction had she worked with this group in particular...As I watched her teach science compared to my reaction that I was getting in here, I just assumed, kind of looked at the fact that I don't think it would have worked as well. (Dawson, Interview, 5/4)

Instead of succumbing to the constraints she perceived, Marie became a catalyst within the system. In planning her future career, this energy for activation was raised to a conscious level. Marie perceived the textbook based curriculum as a major impediment to her science teaching, and wanted to take action to influence the system.

> I'd really like to get on the science adoption committee wherever I end up when they start adopting their new curriculum...You know, you've got to go even further than the adoption, you've got to go to your funding, and how is the budgeting being done. And what I would spend the money on. I would spend $600 on textbooks for science?? I mean there is a whole education of administration that's gotta happen too. And I want to find a district where I can do that. (Interview, 4/20)

Thus Marie saw possibilities for change and recognized her potential as a change agent.

Hybridization: Marie's brand of compliance

In the science curriculum, Marie felt constrained by expectations from her cooperating teachers that she use the textbook, including the accompanying worksheets and tests (see Abell & Roth, 1991). She complied with these perceived expectations, using the textbook to teach a rocks and minerals unit and an oceans unit. Yet her brand of compliance was not without a twist. Marie reflected on her compliance, and attempted to modify the textbook to accommodate her beliefs.

In the rocks and minerals unit, Marie used the text as a guide for planning her instruction, and asked students to read only select portions of the chapter. She felt that in this way the textbook would be more of a resource book than a literature book (Interview, 3/12). Furthermore in both lessons in which the textbook was used, students also had materials to manipulate as they read. For example, before reading a section on igneous rocks with the class, Marie passed out samples of granite, obsidian, and pumice to each group. These were compared to pictures and descriptions in the text.

In the oceans unit, Marie also used alternate textbook strategies. To introduce the unit and develop an anticipatory set, Marie asked the students to skim the pages of the chapter. As they looked, she asked, "What does it look like we're gonna learn?" (Field notes, 4/17). The next day she decided to employ cooperative learning techniques in which each group was assigned a segment of the chapter, given questions to answer, and asked to

present their part of the chapter to the rest of the class. Marie had plans to work on Earth Week activities and do a whale mini-unit within the time the oceans unit was scheduled, so she wanted to move rapidly through the textbook.

> So I wanted to cover this material because I know I've gotta cover it. I've been told that I've gotta cover it. So I didn't want to spend a week on it. (Interview, 4/19)

Accompanying the textbook are chapter tests and worksheet pages. Marie was unhappy with the tests, feeling that they did not correspond with the type of teaching she was doing. "I've looked at it and it's very knowledge level...I don't even know that that's reflective of my teaching" (Interview, 3/16). For both science units that she taught Marie felt obliged to give a test. Yet for each unit she hybridized the test by including performance and attitude assessments along with content items. She also attempted to evade what she considered an overuse of worksheets, in science and other subjects.

> I'm working real hard to get away from worksheets...I'm still working through that. How to be accountable and yet without the purple passion. (Interview, 3/16)

In spelling she developed a spelling club and a class game that cut down on the worksheet load. In science she neglected using worksheets except during the first lesson she taught. Toward the end of the student teaching experience Marie discussed curricular obligations felt by her and a fellow student teacher:

> This is our baseline, I mean doing all the worksheets and everything. This is where we started, where we came in. And so, we're trying to work through that as we can. (Lowering her voice to a whisper) I mean a lot of what I'm doing, I'm doing until I'm told I can't do it. (Interview, 4/17)

Marie's response to worksheets, the science textbook, and its tests resulted in hybrid products that combined the expected strategy with her own beliefs and practices.

Discussion

Lacey (1987) described the active role that student teachers play in their socialization by using the mechanisms of strategic compliance and strategic redefinition in addition to that of internalized adjustment. He argued that the traditional notion of socialization as the process by which individuals change to fit the structure was inadequate to describe teacher change. Feiman-Nemser and Floden (1986) echo this sentiment, portraying novice teachers as active agents in their socialization. Our findings support and extend these ideas.

During student teaching, Marie did not appear to be a passive bystander, buffeted by the forces of cooperating teachers, university supervisors, and the curriculum. She seldom, if ever, demonstrated the strategy of internalized adjustment by complying with constraints and coming to believe

that they were for the best. Instead she created strategies for coping appropriate to her situation.

Lacey stated that strategic compliance was the most common strategy among the student teachers he studied. Students might, on the surface, comply with constraints, but underneath retain their private reservations. In Marie's case, however, this strategy was not commonly used. In the cases where she did comply with perceived expectations, she typically modified her response, producing a hybrid solution to the situation. This strategy most closely matches Lacey's strategic redefinition where students brought their knowledge, values, and skills to bear on a problem.

Marie's other mechanisms for coping with perceived constraints, supersaturation and activation, may also fit the strategic redefinition category, yet they go beyond the examples which Lacey presented. His examples involved students introducing small innovations in the classroom or small deviations to teacher expectations. Marie's strategies were on a much bigger scale. She challenged not only the science class structure by emphasizing group work, but also the overall structure of the school day and week by saturating the curriculum with science. Her activation strategy illustrated that she was not simply fitting in with the established norms, but was influencing those norms as well.

The extent of Marie's strategies for coping with constraints seems incredible when compared with other accounts of novices, both student teachers and first year teachers (see Etheridge, 1989) who more commonly display the internalized adjustment and strategic compliance mechanisms. Furthermore Marie's experience does not seem to fit any of the three scenarios suggested by Zeichner and Tabachnick (1981) to explain the traditional teaching perspectives adopted by beginning teachers. Marie did not begin student teaching with a traditional view of science teaching and was not overwhelmed by school constraints to adopt such a view.

Why is this case unique? One could claim that Marie was affected by the presence of an observer in her class; yet over the length of the observation she would have adjusted to this presence to some degree. Rather we assert that elementary school science might actually be considered an enabling subject for the novice teacher. Elementary school teachers, for a variety of reasons, often feel uncomfortable with science and avoid teaching it (see Abell, 1990). A novice, who is also a science enthusiast, may be able to implement innovations in science more easily than any other part of the curriculum, simply because the cooperating teacher feels so threatened by the existing science curriculum. In Marie's case, her cooperating teacher did not teach science, and the class science teacher stopped observing Marie after her first week of teaching. That left Marie on her own to implement her own brand of science. She did not have to

come in direct conflict with her teacher, and in some eyes was actually seen as a savior to the science program.

Implications

Marie's experience in student teaching was representative of the experience of many elementary student teachers. Yet the case of a science enthusiast is more telling in several ways. We find that novice teachers do not necessarily comply with the cultural norms of the school in which they teach. On the contrary, a science enthusiast may even be able to affect significant changes. The student teacher, far from taking a passive role in socialization, may actively resist compliance and may influence experienced teachers in the process.

If we are entrusting novices to be change agents in schools, then perhaps we should reconsider their preparation programs. In addition to helping them construct a viable philosophy of teaching and learning, learn effective instructional strategies, and reflect on their beliefs and practices, perhaps we should engage preservice teachers in thinking about the process of change in schools. They can become aware of current reform efforts, of leadership for change strategies, and of how to develop collegiate support and coaching for their practice.

Practicing teachers likewise can be empowered to be change agents. This means not only changing systems so that teachers play a role in decision-making, but also helping teachers develop the leadership skills necessary for facilitating change in their schools. For elementary school teachers in science, this will be no easy task. Yet already some curriculum innovators are realizing that the failures of curriculum reform in the sixties may be partially attributed to the oversight of the reformers to prepare teacher leaders. At least one of the current reform efforts in elementary science (BSCS & IBM, 1989) is attempting to integrate notions of change facilitation within schools into their teacher education materials. Efforts such as these will rely on the science enthusiasts in elementary schools as leaders in change.

This study is part of a larger research project in which we are (a) following Marie into her first year of teaching, and (b) examining changes in science teaching practices through a grassroots reform effort aimed at developing peer leaders among her colleagues. The knowledge generated from these studies will provide a basis for implementing broader reforms in science education, taking two key players into account: the preservice teacher who will need to negotiate idealistic beliefs about science teaching within the existing school structure, and the practicing teacher who will be recruited to implement the reforms. Reform movements in science education will only be effective if classroom teachers understand and support them. This study establishes a theortetical base from which we can begin to understand the science enthusiasts among practicing and

prospective elementary school teachers who will help change our schools.

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